S&E SCIENCE AND THE ENVIRONMENT BULLETIN S&E
Issue No. 12 May/June 1999

HARNESSING THE POWER OF LANDFILL GAS

Landfill sites generate over a quarter of the methane emissions caused by human activity in Canada, sending 1.2 million tonnes of this potent greenhouse gas into the atmosphere each year. Because the global warming effect of methane is 21 times greater than that of carbon dioxide, this is the equivalent of greenhouse gas emissions from more than six million cars—or 40 per cent of all the passenger vehicles in the country.

Landfill gas is generated when degradable organic waste buried at a site decomposes without oxygen.

Methane is one of the main components of landfill gas—an odourless, colourless gas generated by the anaerobic decomposition of degradable organic waste. Although its composition can vary, landfill gas is typically half methane and half carbon dioxide, with trace levels of sulphur compounds and volatile organic compounds.

Landfill sites begin producing landfill gas in their first year, and can continue producing for up to half a century.

Over the past decade, innovative technologies have been developed to capture this gas by drilling deep into landfill sites and pumping it out through a network of pipes. The captured gas is either flared off or piped to nearby facilities for use as fuel in heating buildings or generating electricity. Burning landfill gas not only converts methane to carbon dioxide, but also destroys most of its harmful components—which can cause nuisance odours, stress on vegetation, smog, and a risk of fire, explosion and asphyxiation. The methane produced by Canadian landfill sites contains enough energy to heat more than 600 000 homes a year.

Environment Canada has been working with Natural Resources Canada, provincial departments and the private sector to raise awareness of the energy potential of landfill gas by holding workshops and publishing guidebooks on the subject, as well as supporting research into new and innovative technologies. These include a new cryogenic purification process that can separate landfill gas into liquified natural gas and high-purity carbon dioxide, and the use of automobile engines to generate electricity on small landfill sites.

The increased availability of cost-effective and efficient technologies has resulted in a 40-per-cent increase in landfill gas capture in Canada since 1990. Today, nearly 300 000 tonnes of methane are recovered at 33 sites across the country annually, reducing greenhouse gas emissions equivalent to six megatonnes of carbon dioxide. However, this still represents just a quarter of the total landfill methane produced in Canada each year.

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Clean Air Day Canada
June 2, 1999

Environment Canada Environnement Canada

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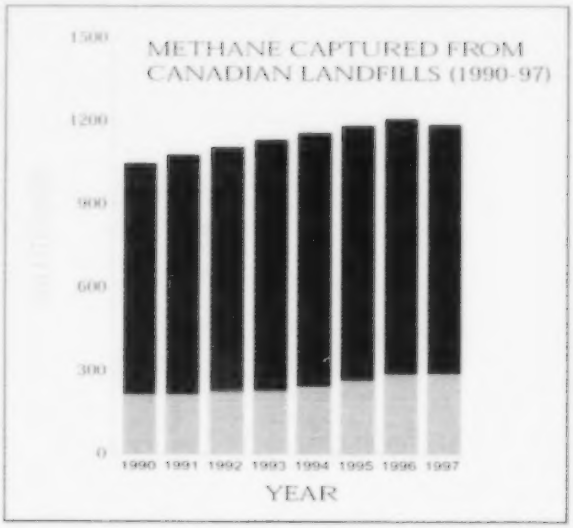


Bars represent total landfill gas generated from all landfill sites in Canada, with portion captured indicated in green.

About 70 per cent of the recovered gas is used as energy, most of it at large-volume landfills located near major urban centres. However, the potential also exists for many medium and small sites to generate revenue from landfill gas recovery projects. Early this summer, a report will be released exploring ways to make landfill gas a more viable and attractive source of energy, and identifying 40–50 sites in Canada that have the greatest potential for the expansion or installation of recovery systems.

Experts estimate that the volume of landfill methane captured in Canada could be doubled within the next five years—significantly decreasing Canada's greenhouse gas emissions, and reducing the impact of human activity on global climate change. For more information on landfill gas, visit Environment Canada's National Office of Pollution Prevention web site at [www.ec.gc.ca/nopp/lfg/bulletin]. S&E

LANDFILL GAS IN ACTION

Jackman Landfill Site — Aldergrove, British Columbia

- since 1995, LFG used to heat commercial greenhouses and provide CO_2 to plants.
- GHG reduction equivalent to 18 000 tonnes of CO_2
- closed site, 0.5 million tonnes of waste.

Port Mann Landfill Site—Surrey, British Columbia

- since 1993, LFG used to fuel dryers in wallboard manufacturing plant.
- GHG reduction equivalent to 40 000 tonnes of CO_2
- closed site, 4 million tonnes of waste.

Clover Bar Landfill Site—Edmonton, Alberta

- since 1992, LFG piped to generating station, where it produces enough power annually for 4200 homes.
- GHG reduction equivalent to 182 000 tonnes of CO_2
- active site, 12 million tonnes of waste.

Keele Valley Landfill Site—Vaughan, Ontario

- since 1995, LFG has operated turbines at electrical generating station; produces enough power for 22 000 households annually.
- power sale nets annual royalties of over $1.5 million for cities.
- active site, 21.5 million tonnes of waste.

Schematic of landfill gas being captured to heat a greenhouse

Complexe environnemental de Saint-Michel—Montreal, Quebec

- since 1996, LFG has operated boilers and steam turbine at electrical generating station; produces enough power for 16 800 homes annually.
- GHG reduction equivalent to 1.1 million tonnes of CO_2.
- gas sale provides Montreal with royalties of over $1 million per year.
- active site, 33 million tonnes of waste.

Lachenaie Landfill Site—Lachenaie, Quebec

- since 1996, LFG used to fuel reciprocating engines at on-site electrical generating plant; produces enough electricity for 2450 homes annually.
- GHG reduction equivalent to 250 000 tonnes of CO_2
- active site, 7 million tonnes of waste.

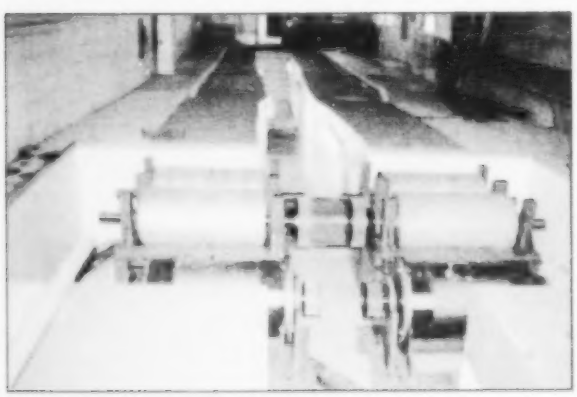
TUNING OUT GREENHOUSE GAS

Ottawa's buses are becoming green machines, thanks to a new diagnostic tool that enables mechanics to detect and correct engine, drive train and brake problems that cause excessive fuel consumption and emissions of greenhouse gases and other pollutants. Developed by engineers at Environment Canada's Environmental Technology Centre, the Multi-Dynamometer Simulator™ could reduce the fleet's fuel consumption by two to three per cent, and save 4000 tonnes of carbon dioxide per year.

OC Transpo is piloting the use of the new Multi-Dynamometer Simulator™ on its fleet of 800 buses.

The dynamometer allows technicians to assess the performance of a vehicle under actual driving conditions—without ever having to leave the garage. The unit is installed in a pit in the garage floor, and consists of two pairs of motorized rollers attached to a computer. The front wheels of the bus sit still while the rear wheels spin on the rollers, which simulate road resistance at speeds of up to 108 kilometres per hour. By comparing the expected power output of the bus with the amount of power that is measured at the wheels, the dynamometer can be used to determine whether or not the vehicle is operating at peak performance. If it is not, a technician can run a barrage of diagnostic tests to determine where the power drain is taking place and correct it.

Based on similar devices used for in-lab emission tests, the Centre's engineers began developing the dynamometer two years ago, after OC Transpo—the region's public transit company—approached them to create a driving simulator that was more flexible and less costly than existing models. What makes their invention unique is that, unlike other dynamometers, it is made up of two independent devices, so readings can pinpoint which side of the vehicle is experiencing power loss due to brake or drive train problems. The dynamometer's computer can also record and store data on the vehicle's performance, rather than simply indicating readings on a gauge, and can be programmed to vary speeds, loads and other parameters automatically.



The dynamometer, which consists of two pairs of motorized rollers attached to a computer, simulates road resistance so that mechanics can assess vehicles under real driving conditions.

At the end of 1998, a prototype was installed at OC Transpo headquarters to pilot the equipment under operating conditions. Used on a daily basis to service the 800-vehicle fleet, the dynamometer has undergone minor adjustments over the past several months, and is now ready to be taken to market. Environment Canada has applied for patent protection for the technology, and has already attracted interest from several firms interested in manufacturing it under licence.

The Department's engineers have also developed a smaller, portable version of the dynamometer for use with cars or light-duty trucks, and believe that the single-axle model currently used for buses could eventually be adapted for use with dual- or multi-axle vehicles such as transport trucks. As the Multi-Dynamometer Simulator™ becomes more widely used, it will make vehicles safer and less expensive to operate, improve air quality, reduce human impact on the climate and conserve our fossil fuels. S&E

PRESERVING CANADA'S WETLANDS

Wetlands are among the most productive habitats in the world. The freshwater edges of lakes and rivers, inland marshes, swamps, sloughs and peatlands, and the marine waters of estuaries and the tidal ocean shoreline are critical habitats for many species of flora and fauna, serve important ecological functions as sinks for natural and human-made pollutants, and are vital to the economy. Unfortunately, these habitats are also severely threatened by drainage, land reclamation, pollution, overuse and other symptoms of human development.

SCIENCE AND HABITAT CONSERVATION

This article is an overview of Environment Canada's work in the area of wetland conservation, and a lead-in to an ongoing series on the role of the Department's science in preserving important habitats across Canada.

On the following page we profile the efforts of the Pacific Estuary Conservation Program to preserve a chain of unique wetlands along the coast of British Columbia.

Home of the longest coastline of any nation in the world, 15 per cent of the planet's freshwater and 24 per cent of its wetlands, Canada is involved in numerous international, national, provincial and local initiatives to conserve its wetlands. Its work is based on more than two decades of science, much of which has been carried out by Environment Canada's Canadian Wildlife Service (CWS) in cooperation with government and non-government organizations.

Since 1981, CWS scientists have been involved in identifying and managing numerous important Canadian wetlands—including those recognized under the Ramsar Convention on Wetlands of International Importance—and ensuring that designated sites are protected now and in the future. An important foundation of this work was the publication of *Wetlands of Canada* and *The Canadian Wetland Classification System*—groundbreaking documents that define the ecology, geographic distribution and management needs of this country's diverse wetland habitats.

Today, Canada has 36 Ramsar sites, representing some 20 per cent of the 70 million hectares of Ramsar-designated wetlands in the world. Through another international initiative—the North American Waterfowl Management Plan—more than $450 million has been invested in conserving Canadian wetlands, most on important waterfowl migration routes. This science-driven continental plan involving Canada, the United States and Mexico is focused on about two million hectares of Canada's most threatened wetland habitats.

In 1991 Canada became one of the first nations to implement a national wetland conservation policy, an example that has since been followed by other countries and has also spurred the creation of provincial policies across our country. In May of this year, the Ramsar Convention adopted a paper—written by an international coalition of wetland experts led by Environment Canada—on fundamental guidelines for implementing national wetland conservation policies. The document will serve as an international standard to the 114 nations to date that are contracting parties to the Ramsar Convention, as well as to others around the world.

As Canada's more than 15 million hectares of protected wetlands continues to grow, scientists are refocusing their efforts on evaluating the effectiveness of existing conservation projects. Because one focus of wetland conservation is to ensure

Arrowhead flourishes in channels between delta islands in the Lac St. Pierre Ramsar site near Sorel, Quebec.

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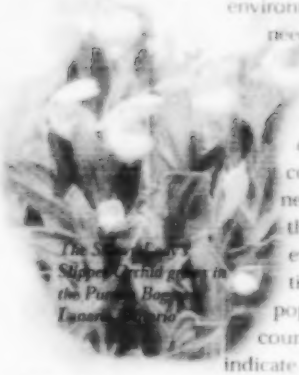
sustainable habitat, the key to success in managing these resources is to balance social, economic and environmental needs.



Monitoring is an essential component of these evaluations, and population counts indicate that many key species, and waterfowl in particular, are responding positively to current habitat conservation efforts.

However, much remains to be learned about the health of these habitats themselves. Further monitoring is required to determine not only if wetlands are disappearing, but also how and why certain ecological characteristics—such as soil and water chemistry, plant health and water conditions—may be changing. Another important area of scientific study focuses on the history of wetlands and the possible long-term impacts of natural and anthropogenic changes. Wetlands play an important role in the carbon cycle, with about 25 per cent of the carbon stored in the world's wetlands found in Canada's peatlands. A clearer understanding of this role is needed in order to determine the fundamental impact that habitat and stored carbon loss would have on global climate.

Environment Canada will be a partner in a special Millennium Wetland Event in Quebec City next year, where more than 2000 scientists and policy makers will have the opportunity to participate in the conferences of global organizations on ecology, peatland, mire and other wetland-related areas. The information shared at this conference and through Canada's involvement in other international conventions on biological diversity, climate change, desertification and migratory species will help to promote effective habitat conservation around the world. S&E

WHERE THE CURRENT MEETS THE TIDE

All along the Pacific coast, the currents of inland waterways meet the tides of the sea in a series of more than 400 estuaries that are among the most productive in the world. Although they comprise less than three per cent of British Columbia's shoreline, these wetlands are used by 80 per cent of coastal wildlife.

Several features make these freshwater-saltwater habitats unique. Tidal fluctuations mean that these temperate areas are sometimes immersed in water and at other times exposed to air. Sandy deltas, where sediment has washed downstream and been deposited at the mouth of the estuary, serve as an ideal growing medium for plants, which, in turn, serve as food and protection to many invertebrates and fish. Salmon use these transition areas to acclimatize their systems as they travel between their saltwater habitat and freshwater spawning grounds.

The Asseek Estuary occupies 67 hectares on the north east tip of Vancouver Island. It is one of several critical estuaries on the rugged coast of British Columbia that are protected under the Pacific Estuary Conservation Program.

This abundance of food makes the estuaries an important migratory stopover and breeding area for millions of waterfowl and shorebirds, and an important habitat for mammals such as deer, elk, cougars, sea otters and bears. The problem is that these delicate ecosystems are also located in the fastest-growing socio-economic region of Canada, and many were subdivided before the turn of the century to provide access to watersheds for logging and mineral exploration. Today, they are threatened by a variety of urban pressures, including industrial development, marinas, float plane terminals, sewage disposal practices, breakwaters and dykes.

To preserve these resources, a coalition of seven government agencies and three non-government conservation organizations formed in 1987 under the Pacific Estuary Conservation Program (PECP) to arrange for the transfer and conservation designation of key lands along the B.C. coast. Identifying which of these areas are most in need of protection has been part of the work at Environment Canada, where scientists have been involved in determining the biological productivity of the estuaries based on the species that live there, and in assessing the imminence of threats from existing or planned developments.

Over the past 12 years, PECP has acquired 1612 hectares of private land and arranged for the transfer and designation of another 54 736 hectares of Crown lands in the estuarine and adjacent intertidal habitats. In May, the partnership program received the Ramsar Wetland Conservation Award for 1999 in the government/non-government coalition category at the Ramsar Convention in San Jose, Costa Rica, in recognition of its exemplary cooperative approach to preserving these precious resources.

MONITORING THE "TAILPIPE OF NORTH AMERICA"

Map showing location of air quality monitoring stations in the three smog forecast regions of southwest, central and southeast New Brunswick.

Visitors to New Brunswick are impressed by its picturesque and pristine natural landscape of lakes, mountains and wilderness. But a stranger from a distant land lurks through the southern half of the province, unseen for the most part by the human eye. Its name is smog, and its presence is making breathing difficult for many residents—particularly children and those with respiratory problems.

Smog, or ground-level ozone, is created when solar radiation interacts with various airborne pollutants and their precursors. Southern New Brunswick receives a significant portion of North America's air pollution, which can travel up to 800 kilometres per day. Approximately 80 per cent of the smog in the province originates from the eastern United States, the Ohio Valley, southern Ontario and Quebec.

To help reduce the impact of smog on human health, Environment Canada scientists in Eastern Canada began to collect data and develop a forecasting model and operational method for predicting smog concentrations. Over the years, the accuracy of these forecasts has increased significantly—not only because of technological advances in the sensitivity of the monitoring equipment, but also because of the innovative use of deterministic as well as statistical numerical prediction models. As knowledge of smog behaviour has increased, the scientists involved have also become better forecasters.

Unlike a typical coastal storm, which migrates up the eastern seaboard and hits each community in its path, a plume of smog may travel the same route, but—depending on local and regional wind velocities, cloud movement, low-level temperature and stability profiles or the impact of fog—could bypass some communities and affect others. These extremes and smog's interaction with regional geographic and climatic variables has led to a greater, more refined and sophisticated understanding of smog by scientists at the New Brunswick Weather Centre in Fredericton.

In 1993, these scientists and their counterparts at the New Brunswick Department of the Environment entered into a partnership under the Smog Advisory Program to provide smog forecasts for the Saint John area. Special bulletins were issued to alert the public when smog concentrations were expected to exceed 82 parts per billion, a level accepted as the national threshold.

The air quality monitoring station at Forest Hills, New Brunswick, has been in continuous operation since 1961, making it one of the oldest in Canada.

Four years later, the success of the program, coupled with the discovery that lower concentrations of smog had a greater impact on human health than previously realized, resulted in its expansion into daily smog forecasts. These forecasts predict smog levels for the next 48 hours—providing air quality readings, categorizing conditions as poor, fair or good, and explaining how weather conditions are affecting the situation. At the end of each forecast, listeners are given advice on how to reduce smog, and directed to visit their physician if they are experiencing air quality-related health problems.

In 1998, the installation of a new monitoring station in Moncton proved that daily smog levels in the city were as significant as those in the more heavily industrialized Saint John region. This May, scientists from the New Brunswick Weather Centre and various provincial departments responded to this discovery by expanding the Smog Forecast Program to the greater Fredericton and Moncton areas. While it is still too early to identify the impact of the program on the health of residents, the issuance of daily smog forecasts enables people in New Brunswick to make informed decisions on how to better protect themselves, their families and the environment from the effects of air pollution. S&E

MANURE CAUSING WHITE HAZE

For years, residents in rural regions of British Columbia's Lower Fraser River Valley were puzzled by the appearance of a thick band of white haze in the sky overhead on calm, sunny days. It wasn't until recently that Environment Canada scientists in Vancouver identified it as a rural version of urban smog associated with intensive agricultural production and, specifically, emissions from poultry and other livestock manures.

White haze over the southern region of the lower Fraser Valley

The haze, which occurs a couple of hundred metres above the ground, can hang around for days—trapped by a cap of warm air that seals off the valley like a lid and obscures the view of the surrounding mountains. Although its health effects are not yet fully known, the direct relationship between fine particles, respiratory disease and mortality has fueled growing concern over this unusual phenomenon.

Manure has been a major concern in the Fraser Valley for some time because of its connection with rising nitrogen levels in local water supplies. To assess the scale of the problem, researchers with the Fraser River Action Plan carried out a series of studies on agricultural nutrient management using census data to determine the quantity of manure and to estimate the amount of nitrogen produced by dairy, swine and poultry farms in the area. After balancing this total with what was going into plants and soil, they discovered that a large quantity was evaporating into the air as ammonia.

Using specialized samplers, the scientists found high concentrations of ammonium sulphate and ammonium nitrate in the air at ground level—evidence that the ammonia was likely combining with nitrogen and sulphur oxides from industrial pollutants and vehicle emissions. When the moisture in these compounds evaporates, the fine particulates that remain are visible as a milky haze. Some of these particles fall to the earth or are washed out in rain, so they can re-enter the cycle again and again.

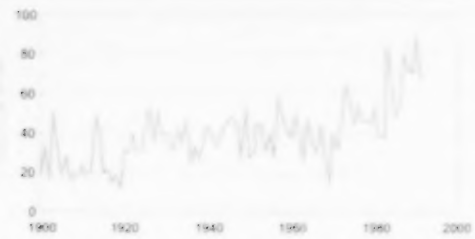
Breeze
Urban Smog
Ammonia from Manure
Combine to Create White Haze
Ammonia from manure volatilizes into the atmosphere and reacts with particles of urban smog to create white haze.
Manure Spreader
Crops

Although the scientists have not yet sent an aircraft through the haze to confirm their theory, they have tested it using a computer model to track air parcels moving away from Vancouver and through the Fraser Valley. As they pass over Abbotsford, an area of intense poultry farming, these parcels of air have been shown to pick up high levels of ammonia. While white haze has not yet been reported elsewhere in Canada, it is also a common phenomenon in farming regions of Colorado.

Environment Canada is working with agricultural producers and other stakeholders to find solutions to this and water contamination problems, including transporting manure out of the area to nitrogen poor regions, changing poultry diets to reduce the nitrogen content of manure, or using it as an additive to commercial fertilizer. In the meantime, scientific data on white haze are being used to develop airshed management plans and encourage stricter controls on nitrogen and sulphur oxide emissions in this rapidly growing region of the country. S&E

2010: AN ATMOSPHERIC ODYSSEY

With the new millennium mere months away, predictions about what the world will be like in 2010 are a far cry from the futuristic visions of Arthur C. Clarke's epic novel of the same name. But, according to a new assessment by scientists at Environment Canada, the state of our atmosphere will change significantly over the next decade.



The frequency of winter storms in the southern hemisphere has increased dramatically since the early 1960s. This trend has also been evident in other extreme weather events, such as droughts and floods.

Atmospheric Change in Canada: An Integrated Overview takes a holistic approach to predicting what Canada's atmosphere will be like 11 years from now based on current environmental targets. And it identifies the need to assess the whole atmosphere in developing human, social, environmental and economic strategies to cope with the expected changes.

What makes the study unique is that, instead of focusing on a particular area of study, it examines all of the relevant atmospheric issues and how they affect one another—including climate variability and extremes, climate change, acid precipitation, stratospheric ozone, ground-level ozone (smog), hazardous air pollutants, and particulates. It then uses this information to hypothesize on how changes in certain areas would affect others—for example, if oil furnaces were replaced by natural gas ones to reduce greenhouse gases, the effect it would have on acid rain and smog, and its impact on Canada's environmental goals.

So what does the future hold? Although air quality will be improved and greenhouse gas emissions reduced below 1990 levels, people will have to slap on more sun protection lotion, since stratospheric ozone will be at its thinnest level ever—with a gradual recovery anticipated beyond 2010. Temperatures are also expected to rise as global warming will be slowed but not stopped in the near future.

The report also indicates that there will be more losses from natural disasters. Over the last 30 years, the world's population has grown by 25 per cent, yet statistics from the world's largest insurance firm indicate that economic losses from severe floods, droughts, ice storms and other calamities have increased 43 per cent over the same period. Eastern Canada is particularly vulnerable to acid rain, especially during droughts, which cause re-acidification or delay the recovery of lakes. By 2010, sulphate deposition will still exceed critical loads, causing chemical changes that will lead to long-term harmful effects on ecosystems.

Although the report indicates that Canada is headed in the right direction in dealing with atmospheric change, the real work is just beginning. Unified atmospheric models and other integrated mapping assessments are needed to fully understand the linkages between the many atmospheric issues and their close relationship with weather patterns. S&E

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SCIENCE AND THE ENVIRONMENT BULLETIN

is a bi-monthly publication produced by Environment Canada to provide information on leading-edge environmental science and technology to Canadians.

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For more information on a subject, you can search all of the on-line resources available from Canada's four natural resource departments — including *S&E Bulletin* — by using the CanExplore search engine at [www.canexplore.gc.ca].

Media representatives and others interested in conducting further research may obtain the names and phone numbers of departmental scientists involved in these and related initiatives by contacting the *Bulletin's* editor, Paul Hempel. He can be reached by e-mail at Paul.Hempel@ec.gc.ca and by telephone at (819) 994-7796. Readers are welcome to e-mail their comments and suggestions to this same address.

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